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# THERMAL DESIGN PARAMETERS and SIGNIFICANCE OF SPREADING

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# Outline

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Recent trend in consumer electronics

Tablet construction / teardown

Quick overview of earlier work

Spreading enhancements in forced convection tablet

- Use of blowers and outer surface spreading

- Experimental study : Baseline and Spreading enhancements

- Results

- Use of blower : Impact on battery life

- Use of blower : challenge miniaturization

- Thermal Design and impact on tablet weight

# Tablet Construction / Teardown



Heatpipes and blowers



CPU and GPU



Batteries

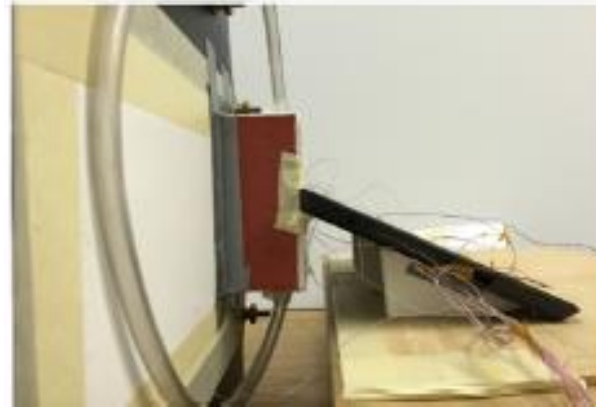


Rear case

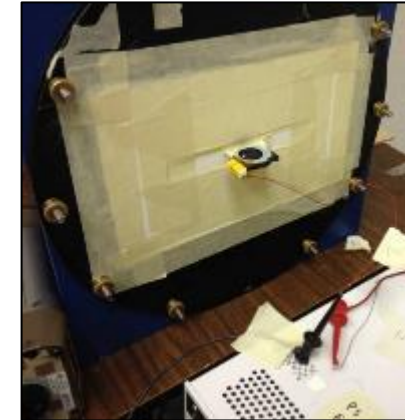
# Quick overview of earlier work



Teardown



Airflow measurement



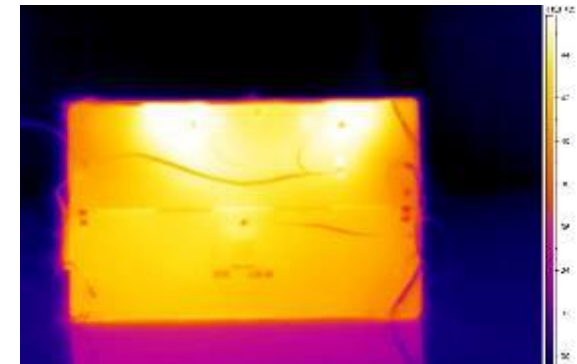
Blower  
characterization



Thermal  
characterization

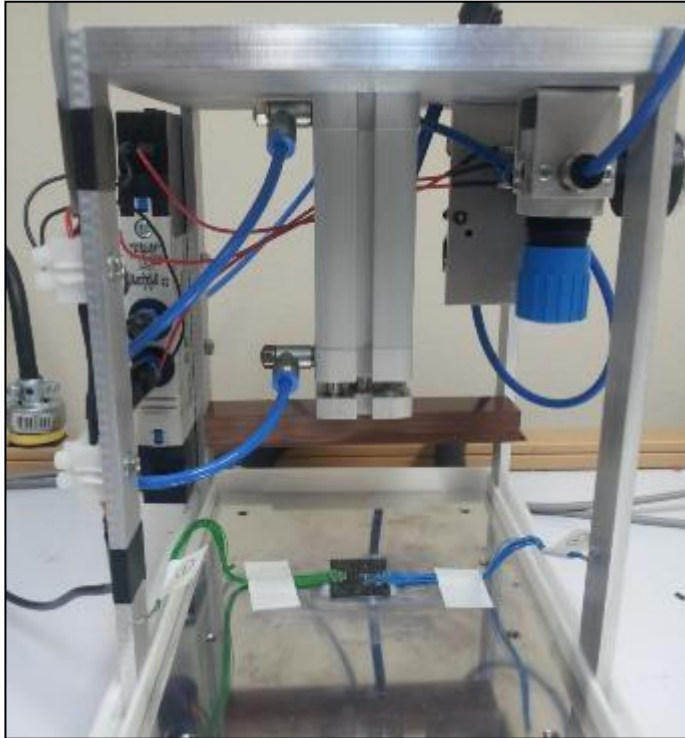


IR imaging



# Quick overview of earlier work

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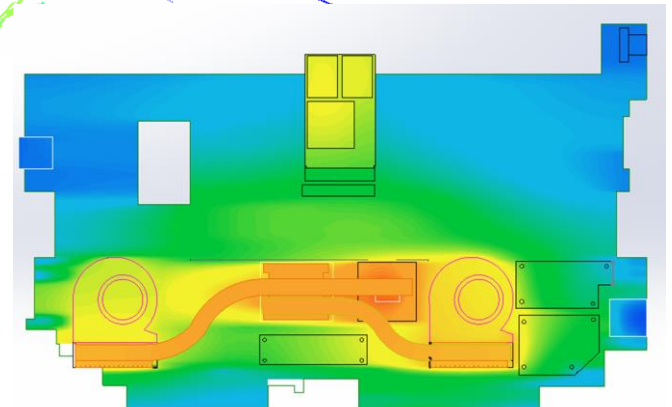
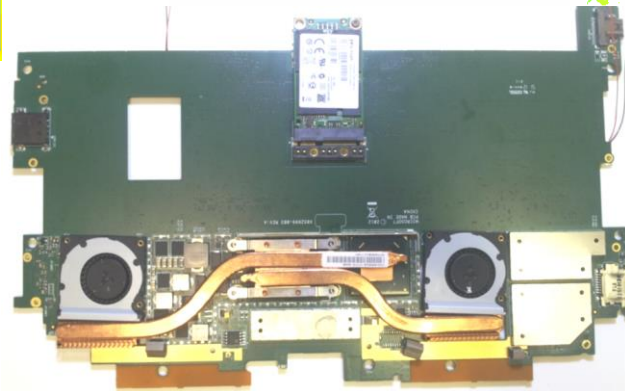
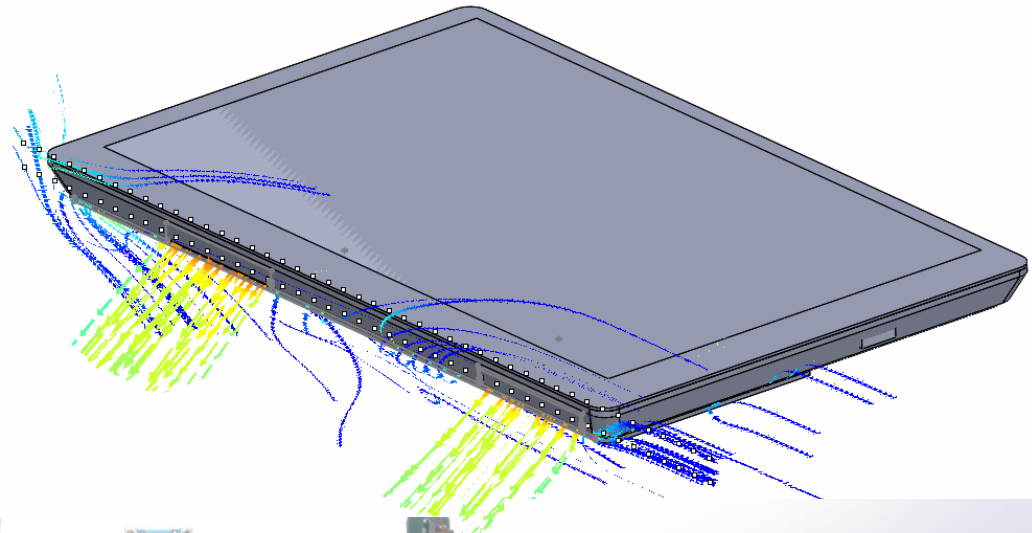
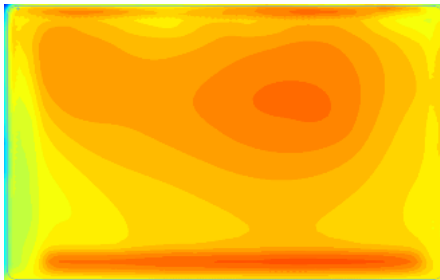
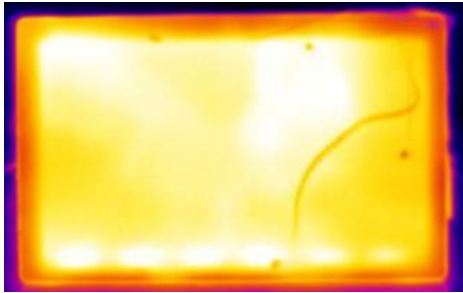
T3ster characterization



Acoustic measurement

# Quick overview of earlier work

Construction of a CFD model in FloTherm XT



# Use of blowers and outer surface heat spreading

## Outer Surface Heat Spreading

### Max. Surface Temperature

Hot spots  
Effective outer surface spreading

### Battery Isolation

Max. battery temperature

### Weight

Material selection of outer surface  
Use of graphite spreader

## Use of Blower

### Blower Speed

Blower noise to users  
Mic. Disruptions due to blower operation  
Blowers, heat-pipes, heat exchanges add weight

### Blower Plenum

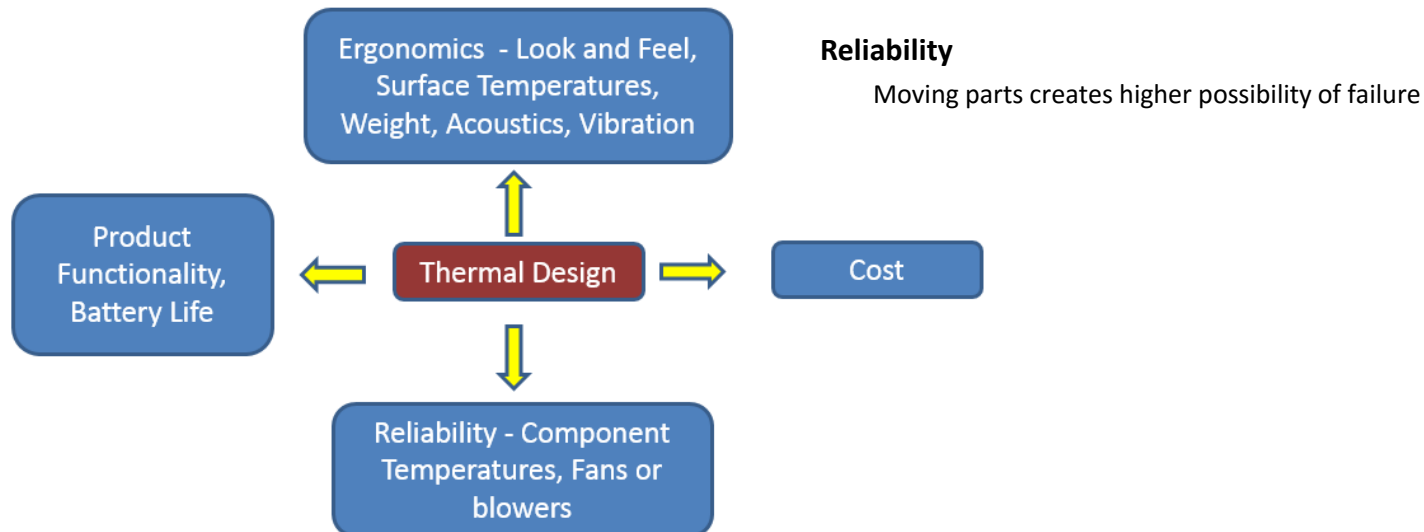
Blower is effective with adequate plenum, but increases tablet thickness

### Battery Life

Blowers add parasitic load to the already short battery life

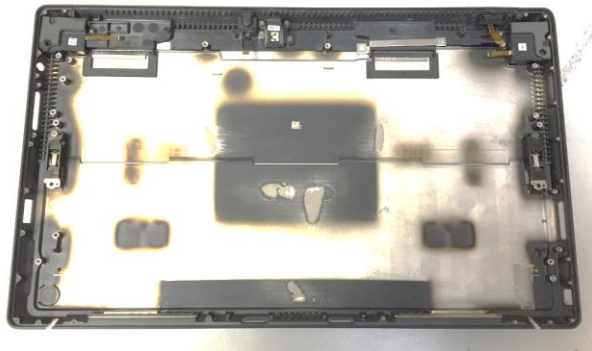
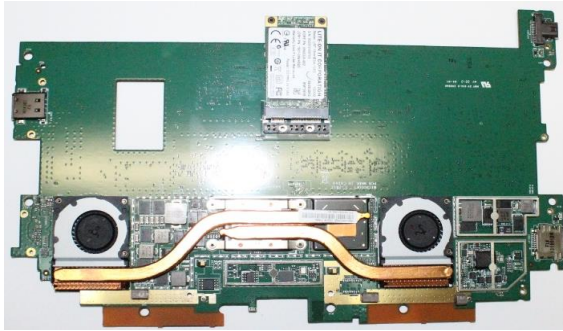
### Reliability

Moving parts creates higher possibility of failure



# Experimental Study : Heat spreading configurations

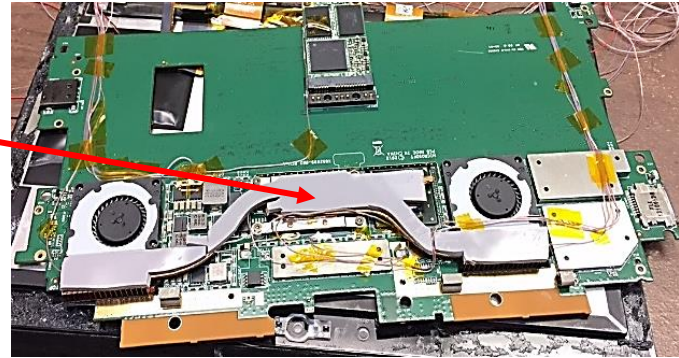
Case 1  
Baseline



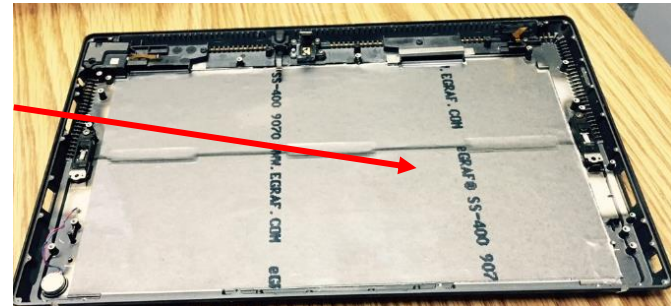
Blowers and  
Magnesium rear case

Case 2  
With Spreading enhancements

TIM  
Connected to  
rear case



Graphite  
spreader

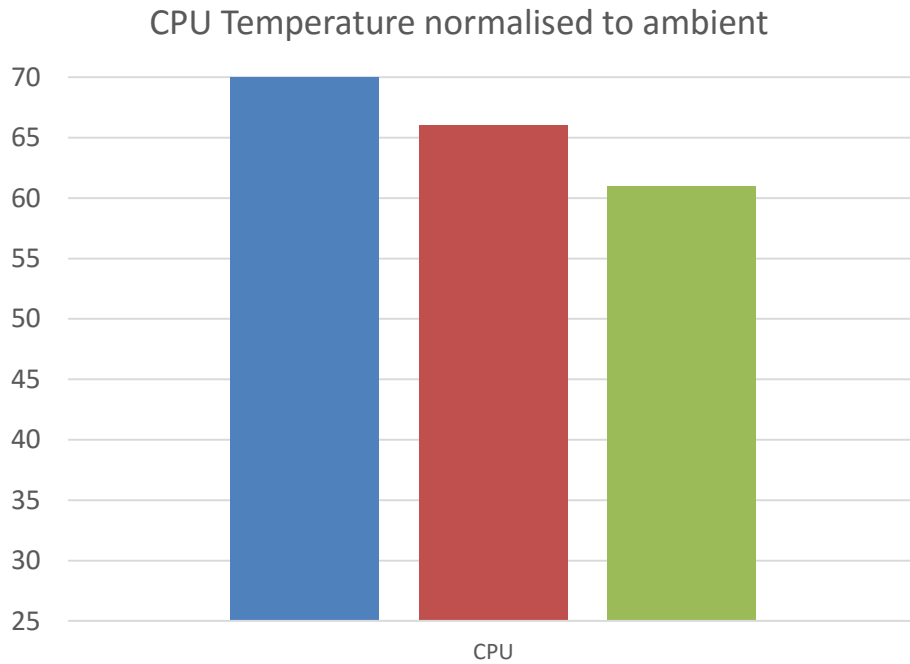


+ Conduction path through TIM  
between heat-pipe and rear case

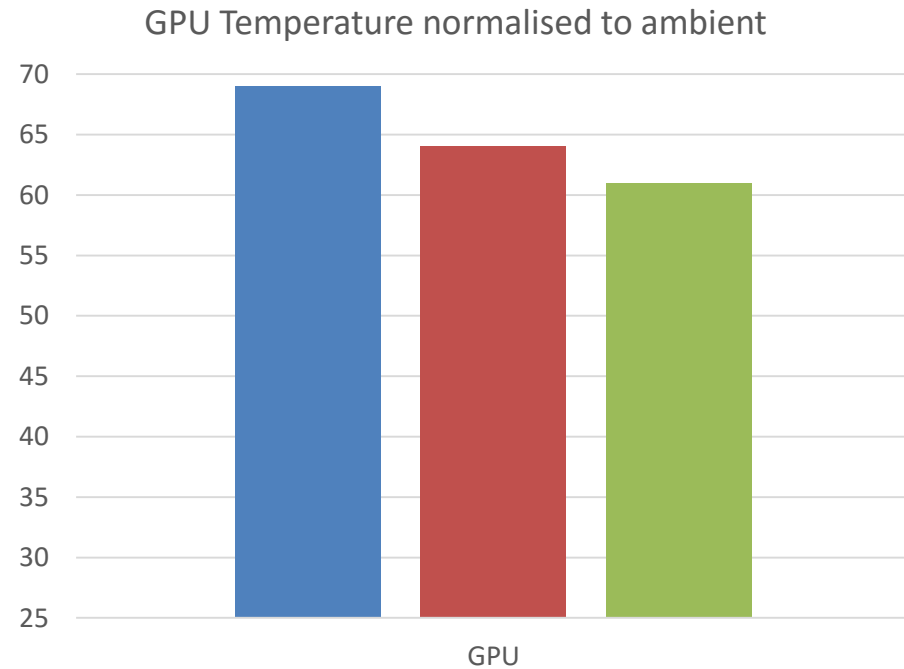


# CPU and GPU temperatures

## CPU Temperature



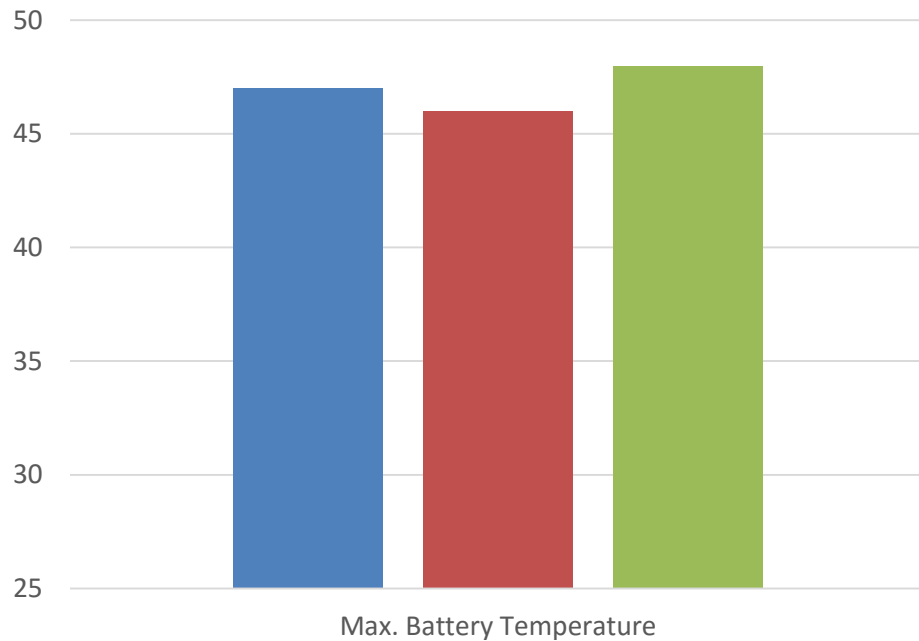
## GPU Temperature



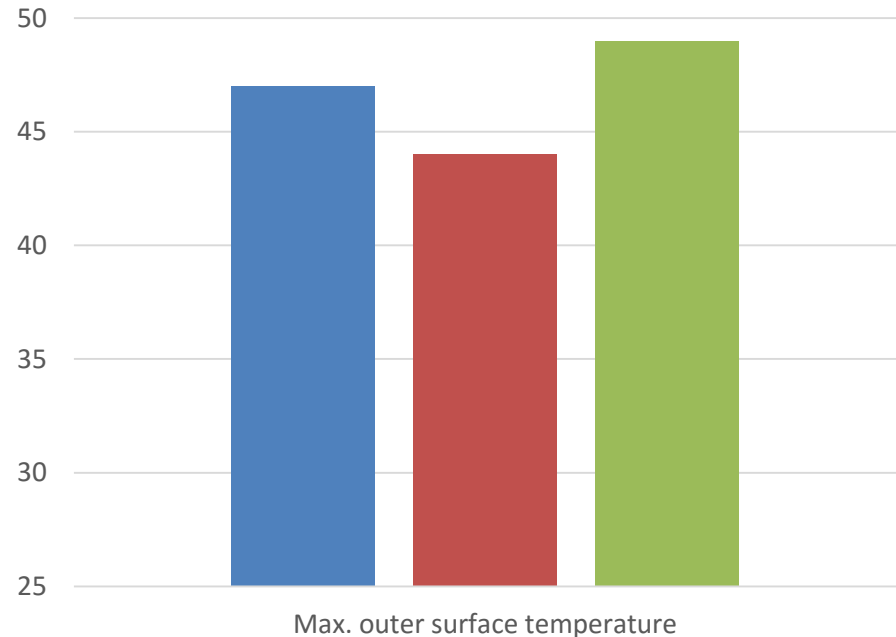
- Baseline (case 1) with Blower @ **3900 RPM**
- Baseline (case 1) with Blower @ **8900 RPM**
- Enhanced Spreading (case 2) with Blower @ **3900 RPM**

# Max. outer surface temperature and battery temperature

## Max. Battery Temperature



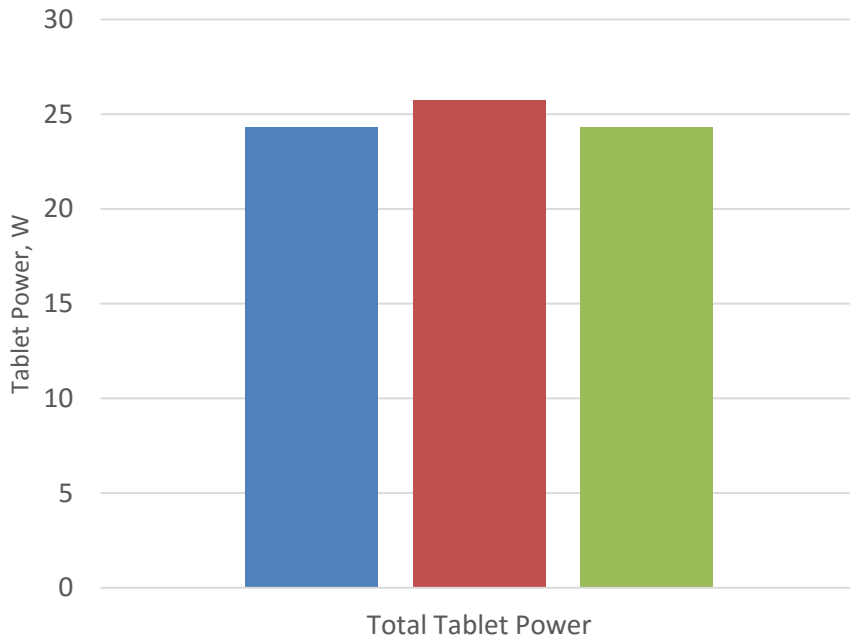
## Max. Surface Temperature



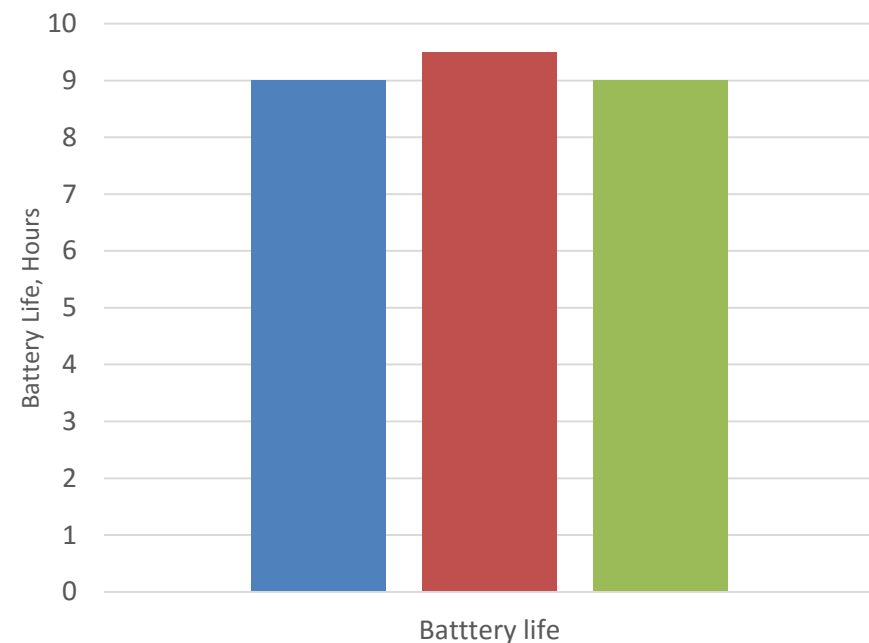
- Baseline (case 1) with Blower @ **3900 RPM**
- Baseline (case 1) with Blower @ **8900 RPM**
- Enhanced Spreading (case 2) with Blower @ **3900 RPM**

# Tablet power and battery life

## Total Tablet Power Consumption



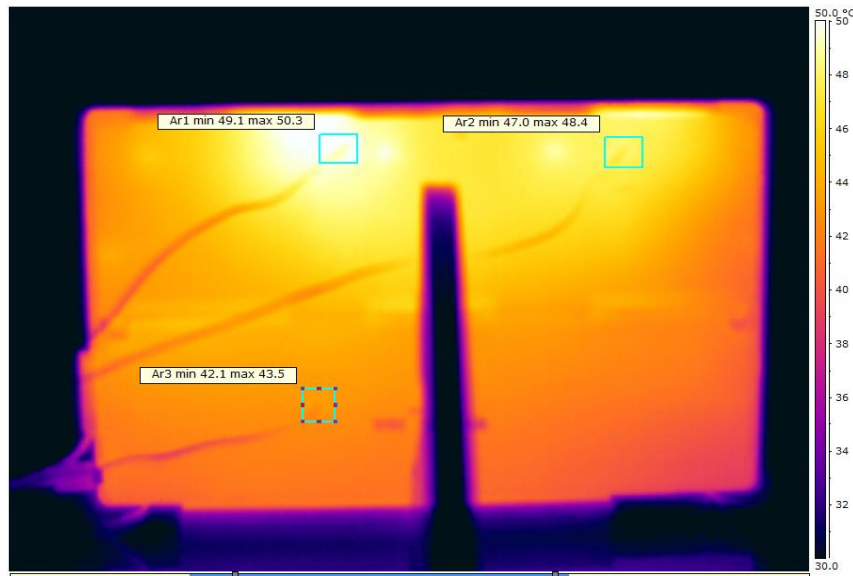
## Battery Life



- Baseline (case 1) with Blower @ **3900 RPM**
- Baseline (case 1) with Blower @ **8900 RPM**
- Enhanced Spreading (case 2) with Blower @ **3900 RPM**

# IR images for with and without spreading enhancements

Baseline (case 1) with Blower @ 3900 RPM



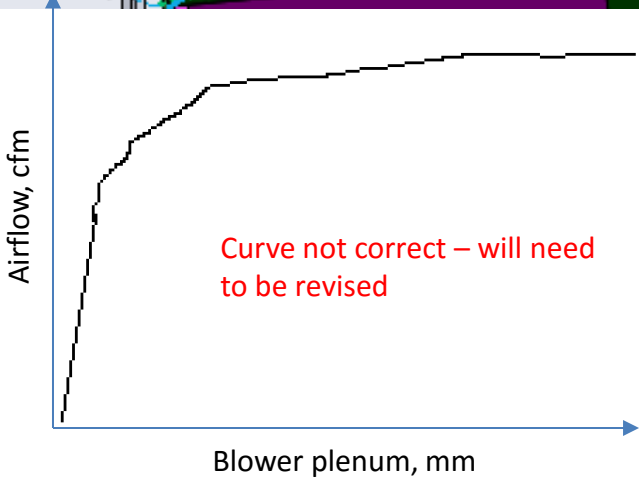
Enhanced Spreading (case 2) with Blower @ 3900 RPM



Rear case

# Use of blower : challenge miniaturization

**Blower needs adequate plenum to operate effectively**

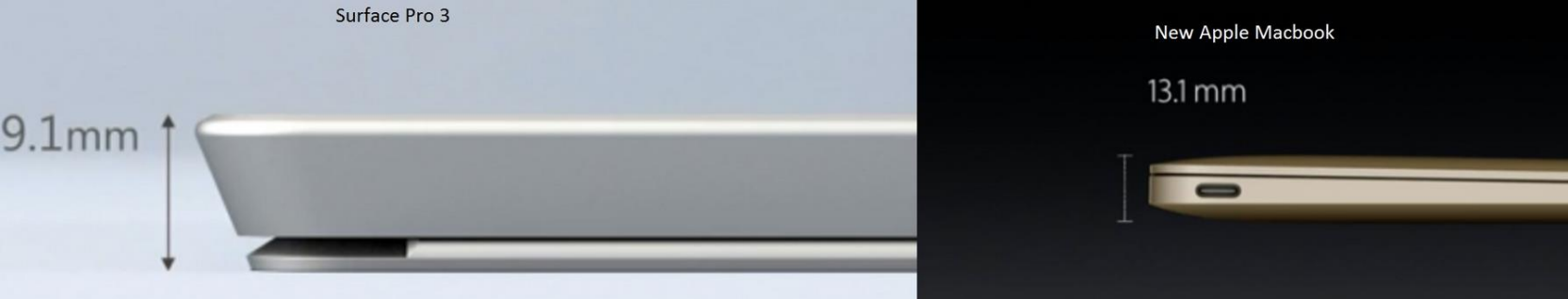


<http://www.phonearena.com/image.php?m=Reviews.Images&f=name&id=146115&popup=1>

# Use of blower : challenge miniaturization



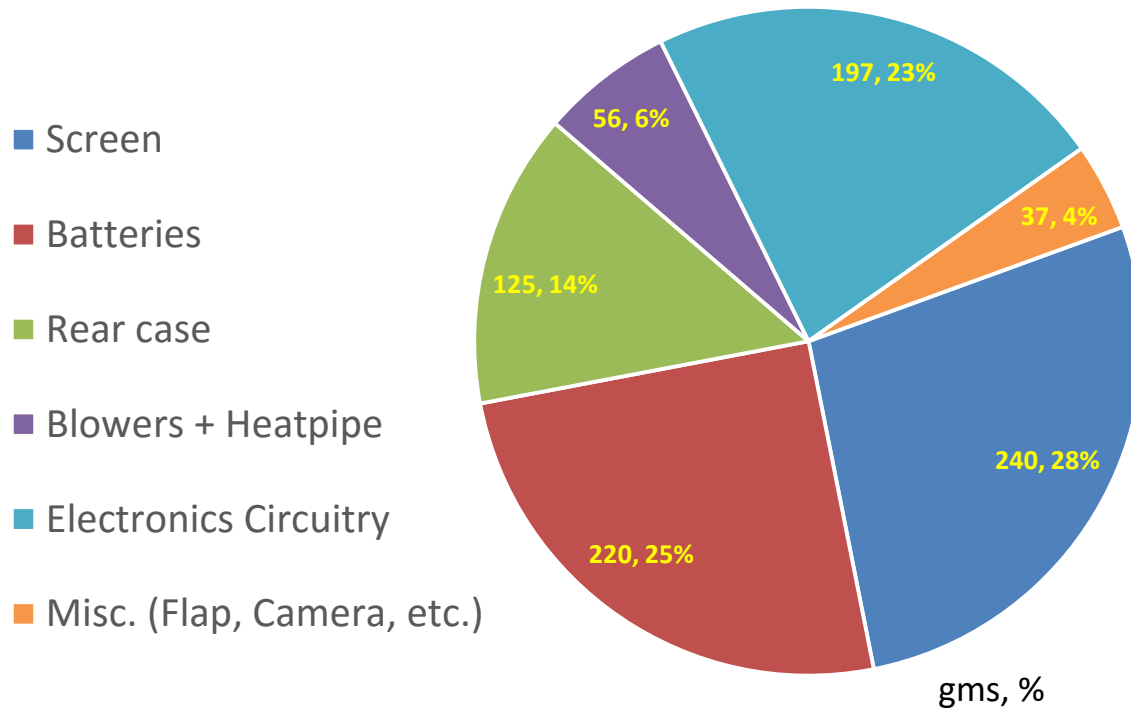
Source: <http://www.phonearena.com/image.php?m=Reviews.Images&f=name&id=146115&popup=1>



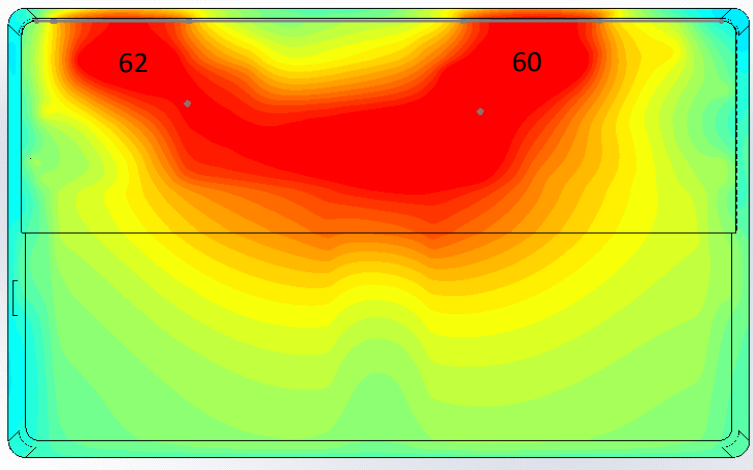
Source: <http://microsoft-news.com/apple-macbook-vs-microsoft-surface-pro-3-spec-comparison/>

# Weight Distribution in the Tablet

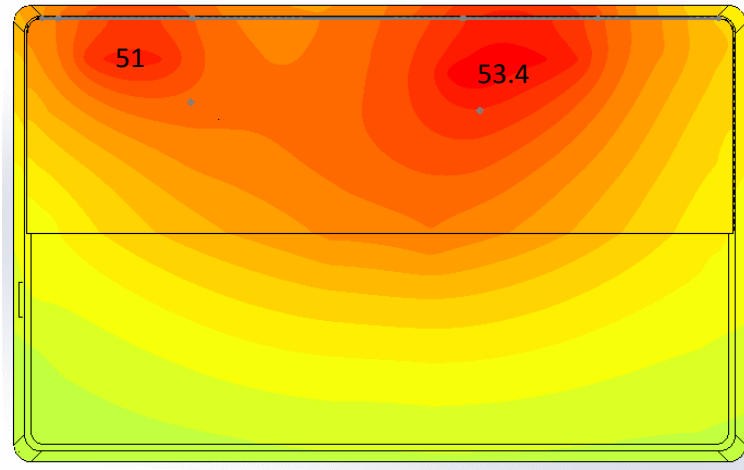
Weight Distribution in Tablet



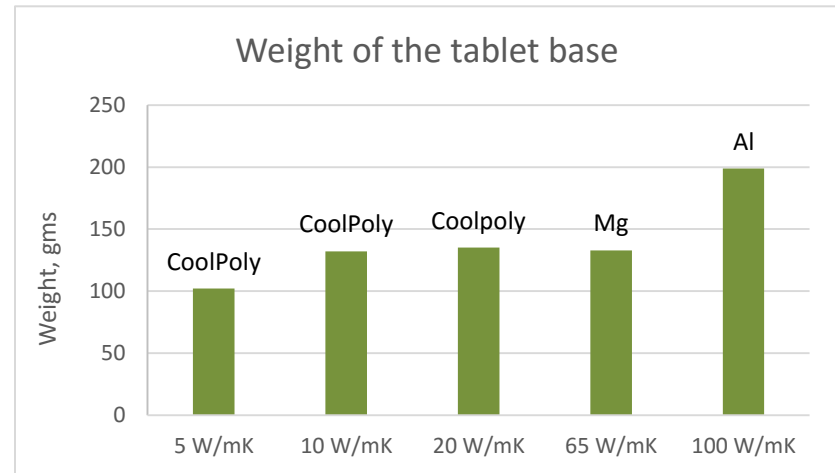
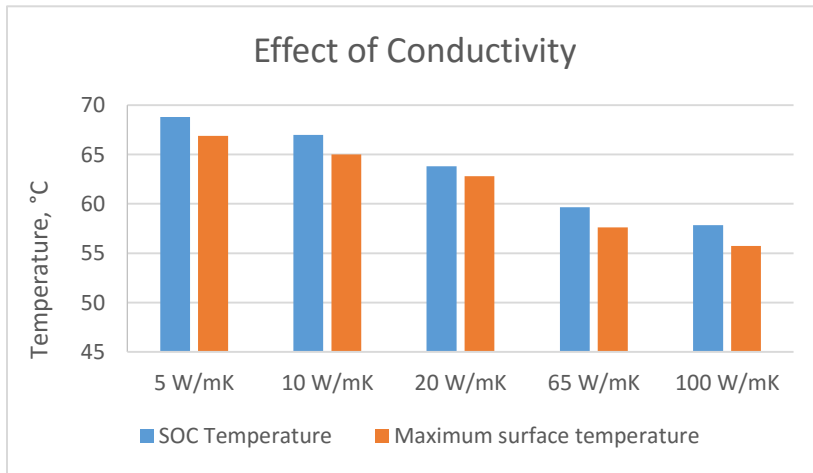
# Evaluation of Al, Mg and High Conductive Plastics



Conductivity - 5W/mK



Conductivity - 100 W/mK



Simulation for Baseline case



# References

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- [2] Brown, L., Seshadri, H., Cool Hand Linux® - Handheld Thermal Extensions, Proceedings of the Linux Symposium, Vol. 1, pp 75 – 80, 2007
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- [4] Huh, Y., Future Direction of Power Management in Mobile Devices, IEEE Asian Solid-State Circuits Conference, 2011.
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- [6] Mongia, R., Bhattacharya, A., Pokharna, H., Skin Cooling and Other Challenges in Future Mobile Form Factor Computing Devices, Microelectronics Journal, Vol. 39, pp 992 – 1000, 2008
- [7] Wagner, G and Maltz, W “Tablet Natural Convection Cooling Efficiency” Engineering Edge, pp 10-15, vol 2, issue 1, 2013.

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Thank you!

Questions?